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EXCITATION OF LOWER HYBRID WAVES IN A FINITE PLASMA.(U)
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(6) EXCITATION OF LOWER HYBRID WAVES IN A FINITE PLASMA.

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ABSTRACT

A computer simulation study of the launching of lower hybrid waves by external sources and their propagation in a finite but homogeneous plasma slab is presented. The study makes use of a 2-1/2 dimensional, electrostatic particle code developed for simulation of bounded plasma. A number of antenna configurations are considered: a point source, two finite-length capacitor plates, and a phased array of capacitor plates. When the oscillating frequency does not match a bounded plasma resonance, one can observe resonance cones, energy absorption at the plasma surface, ion cyclotron modulation of the source, and energetic ions, depending on the parameters chosen. The excitation of a bounded plasma resonance is also considered. The nonlinear evolution of the resonance shows that wave-particle interactions and ponderomotive force effects play an important role. The possibility of controlling the electron temperature profile is discussed.

I. INTRODUCTION

Plasma heating by lower hybrid waves has been considered extensively over the past decade.[1-14] The technological advantages of this scheme are: (1) RF generators exist which can deliver large amounts of power at the frequencies required; (2) the coupling to fusion devices can be implemented through waveguides which are remote from the neutron environment. However, if this scheme is to be useful, a number of plasma physics questions must be solved. There is the problem of effectively coupling the RF energy to the plasma at the edge, especially at the power levels required.[2,3] Further, one must understand what happens to the wave as it propagates to the resonance layer, especially at large wave amplitudes, where many nonlinear effects may be important.[4-7] Thirdly, if the RF energy can penetrate to the resonance region, there is the problem of what linear and/or nonlinear effects occur in the lower hybrid regions.[1,8-12] Finally, the processes by which the energy of the wave is absorbed by the plasma, and the subsequent thermalization of the energy must be understood.[11-13]

Computer simulation can be a useful tool in understanding the physics in this problem, especially when nonlinear effects are important and are difficult to treat analytically. Present day computers are not large enough nor fast enough, however, to handle all the different scale lengths necessary in simulating the entire lower hybrid heating scheme. Instead, one must at present be satisfied with simulating certain parts of the scheme separately, such as the coupling of the radiation at the edge, or the wave conversion in the plasma interior. One can nonetheless identify the important kinetic and nonlinear effects in each area and thus contribute to the understanding of the overall problem. As a first step in a systematic study of the lower hybrid heating scheme, we present here a

computer simulation study of the launching and propagation of lower hybrid waves by external sources and their propagation in a finite but homogeneous plasma slab bounded on both sides by vacuum.

The computer model and simulation parameters are discussed in Sec. II. Non-resonant oscillations excited by various sources are discussed in Sec. III. In Sec. IV the excitation and nonlinear evolution of a bounded plasma resonance are studied. Finally, a summary is contained in Sec. V.

II. COMPUTER MODEL

An electrostatic particle simulation model, described in detail elsewhere,[15] has been developed for this study and is briefly summarized here. The two dimensional electrostatic model is periodic in one dimension and bounded in the other. In the non-periodic dimension one can specify the values of the potential or the normal electric field on both boundaries. It is also possible to specify that a vacuum exists outside the plasma, or any combination of these conditions on each boundary separately. External electrostatic sources (i.e. charges not belonging to the plasma) can be added in a natural way either on the boundaries or in the plasma interior. Finite-sized (Gaussian) particles are used throughout, and all three velocity co-ordinates are retained in the calculations.

For the simulation results presented here, the following parameters and conditions were specified: Vacuum boundary conditions were imposed in the $\hat{x}$ direction on both sides of the slab. External sources, described below, are specified on one boundary. The external magnetic field was oriented in the periodic ($\hat{z}$) direction with ratio of electron cyclotron to plasma frequency $\Omega_e/\omega_{pe} = 1$, and ion-electron mass ratio $M_i/m_e = 64$. In most cases the ions were colder than electrons with $T_e/T_i = 10$ (except for the case of Fig. 4 where $T_e = T_i$). Particles were initially uniformly distributed within the slab with Gaussian velocity distributions, and they were reflected elastically from the boundaries, with the full dynamics calculated correctly to second order in the time step $\Delta t = 0.2\ \omega_{pe}^{-1}$. The reflection of particles implies that there is no mechanism for net energy loss in the system. The size of the system in the $\hat{x}$ and $\hat{z}$ directions was $L_x/\lambda_{De} = 32$, $L_z/\lambda_{De} = 128$.

The external source in these simulations was determined by specifying an external surface charge density on one boundary of the slab, oscillating

with a specified frequency ω_o. Because the magnitude of the charge density is fixed externally, such a source corresponds to a constant current driver. In all cases, the phase of the oscillator was chosen so that the external field was zero at t = 0, and the amplitude was kept small so that the plasma response could be described, at least initially, by a linear theory. The strength of the oscillator was normalized in terms of a parameter w, the energy of the source in vacuum integrated over the plasma area A divided by the electric field fluctuation energy of the plasma when in thermal equilibrium and free of external sources,

$$w \equiv \frac{1}{A} \int E_{ext}^2 dA / \sum_k |E_k|^2 . \tag{1}$$

In the computer model for the parameters chosen, the thermal electric field fluctuation energy density is about 100 times smaller than the particle kinetic energy density. The reason for this particular normalization is that the plasma response is determined by the length and distribution of the external charge, as well as its magnitude, and all these factors are included in w.

III. NON-RESONANT OSCILLATIONS DRIVEN BY AN EXTERNAL SOURCE

It is well-known that the normal modes of oscillation of a bounded plasma form a discrete set.[16] Therefore, the plasma will respond differently depending on whether or not the frequency and a wavenumber of the spectrum excited by the source match simultaneously the frequency and wavenumber of one of the normal modes of the plasma. For perfect matching, the electric field for the single resonant mode grows secularly with time until some nonlinearity stops the growth . If there is a mismatch, the plasma responds with non-resonant driven oscillations. Since a finite size driver contains a spectrum of wavenumbers, there will generally be a response of many non-resonant modes even when one mode satisfies the resonance condition.

The typical non-resonant plasma response to a number of "antenna configurations" of external sources will be considered next, along with the significant kinetic and nonlinear effects. Special attention will be paid to the coupling of the source to the plasma at the surface, the spatial distribution of the heating, and the evolution of the velocity distribution.

A. Point Source Antenna and Lower Hybrid Resonance Cones

A well-known feature of the propagation of lower hybrid signals is the existence of resonance cones.[4,5] These cones arise because for a given frequency, the group velocities away from the source for all wavenumbers with the same sign are parallel, in the cold plasma limit. In order to clearly observe resonance cones in a model which is periodic in one direction, it is necessary that the cones from each of the periodic sources must interfere constructively. In addition, the frequency and wavenumbers of the source should not correspond to some bounded plasma mode in order to avoid a single mode dominating the plasma response. Since a resonance cone is composed of the sum of many Fourier modes, a point source (actually a line source in

three dimensions) was chosen as the driver in this case, because it contains a broad band spectrum. A driving frequency which satisfies the above conditions was then chosen ($\omega_o = 2.7\ \omega_{pi}$). The parameter w specifying the strength of the driver was set equal to 2/3.

The system was followed for about 11 oscillation periods. It was found that the resonance cones were set up in about one oscillation period, but the amplitude of the potential oscillations was rather weak. In order to see the cones clearly, the potential at every point in space was Fourier analyzed in time to extract the plasma response at the driver frequency ω_o. The result is shown in Fig. 1. The two cones are clearly seen, and make an angle $\theta \approx 27°$ with respect to the magnetic field; however, they are broader than expected from cold plasma theory. The reason the cones are broad is that the shorter wavelength components of the potential are quickly absorbed by electron Landau damping at the surface.

The resonance cones shown in Fig. 1 can be Fourier analyzed in the parallel direction. This analysis shows that although the point source has a broad spectrum of wavenumbers, only the three largest wavelength modes appreciably contribute to the cones in the plasma interior. The remaining modes, whose parallel phase velocities satisfy $\omega_o/k_m \lesssim 2.5\ v_{th}$, are absorbed at the surface. (The parallel wavenumber is given by $k_m = 2m\pi/L_z$ for integer m and $v_{th} = \sqrt{kTe/m_e}$ is the electron thermal velocity.)

The simulation results reveal a number of other important effects. In Fig. 1, one can observe the dramatic potential drop due to the plasma sheath surrounding the source. The effect of the sheath is to further reduce the penetration of the source. Examination of the time evolution of the total electric field energy w_{ef}, shown in Fig. 2 and normalized to the kinetic energy of a thermal electron by

$$w_{ef} \equiv \frac{\tilde{\lambda}_{De}^{2}}{kT_e} \int \frac{E^2}{8\pi}\, dA, \tag{2}$$

where $\tilde{\lambda}_{De}$ is the dimensionless Debye length, reveals another interesting kinetic effect. Superimposed on the driven oscillations, there is a modulation of the pump at twice the ion cyclotron frequency Ω_i, which manifests itself as a modulation of the electric field energy at $4\Omega_i$. For all the non-resonant cases studied, a modulation at the ion cyclotron frequency or its first harmonic was observed whenever the physical length of the driver was comparable or smaller than the ion Larmor radius. Although this modulation effect needs further study, it is probably due to ion kinetic effects (ion Bernstein modes) being excited in the sheath region, perhaps due to the sudden turning on of the pump.

The kinetic energy of each species α is normalized in the same manner as the electric field energy, according to

$$w_\alpha \equiv \frac{\tilde{\lambda}_{De}^{2}}{kT_e} \frac{1}{2} m_\alpha \sum_j v_j^{\,2} \tag{3}$$

where the sum is over the particles of species α. The evolution of the electron kinetic energy w_e (Fig. 3) shows a net energy gain of about 5% after 11 oscillation periods, with the gain all due to the increase of parallel velocity. The slight undulations in the growth coincide with the ion cyclotron harmonic modulation noted previously. The distribution of energy was not spatially uniform, however. The parallel thermal velocity of electrons confined to the region near the source increased by 20%, whereas the thermal velocity of particles on the opposite side of the slab increased less than 2%. Although a few fast electrons were formed, the heating occurred mainly in the bulk of the velocity distribution. The rate of energy gain of the cold ions, also illustrated in Fig. 3, was given by

$$(\omega_{pe}T_e)^{-1}\frac{dT_i}{dt} \simeq 7\times10^{-5} . \qquad (4)$$

This is about the same rate observed when no source is present. Further, the energy of the ions stayed spatially uniform. This indicates that the energy gain of the ions must have been due to collisional heating with the warm electrons. The driving frequency in this case was too high for much direct ion response.

B. Short Capacitor Plates as Antenna

For the case of the point source, it is apparent that electron Landau damping at the surface plays an important role in the excitation of lower hybrid waves in the plasma interior. This "filtering" effect of the plasma surface is even more dramatically demonstrated here, where two short capacitor plates oscillating out of phase are used as the external source. The frequency ($\omega_o = 2\omega_{pi}$) and length of the source was chosen so that the wavenumber spectrum had a maximum around those modes whose parallel phase velocities were near the electron thermal velocity v_{th}, and the strength of the driver was chosen so that $w = 4/3$. The equipotential lines for the capacitor plates in vacuum are illustrated in Fig. 4(a).

The computer plasma was followed for about 12 oscillation periods, and the steady-state plasma response at the driving frequency is shown in Fig. 4(b). The simulation results show that most of the modes are absorbed at the plasma surface, and only the longest wavelength mode is able to penetrate to the plasma interior. Figure 4(c), which shows the plasma response predicted by cold plasma theory for the excitation of the single mode $m = 1$, verifies that indeed only that mode was excited in the simulation. In other respects, such as the presence of the plasma sheath surrounding the exciter, the modulation of the source at the ion cyclotron frequency, and the evolution of the plasma heating, the results here are similar to those of the point source.

C. Phased Array of Capacitor Plates as Antenna

A phased array of capacitor plates has also been used as the exciting structure. The frequency ($\omega_o = 2\omega_{pi}$) and length of each element was chosen so that the wavenumber spectrum was sharply peaked around a single mode whose parallel phase velocity was $\omega_o/k_m = 1.3\ v_{th}$, which should lead to a strong interaction of the electrons with the exciting structure. To enhance this interaction, the strength of the driver was increased to $w = 10$. The equipotential lines for the phased array in vacuum is illustrated in Fig. 5(a). The computer plasma was followed for 12 oscillation periods, and as shown in Fig. 5(b), there exist no driven oscillations in the plasma interior.

The major observations in this case are the familiar electron surface heating and the presence of significant ion heating, which is also largest at the plasma surface. The electron kinetic energy w_e, illustrated in Fig. 6, shows an energy gain of 20% after $\omega_{pe}t = 300$, mostly due to an increase in the parallel velocity. The energy gain was localized in space to within a few electron Larmor diameters of the source, as shown in Fig. 7.

The ion heating, on the other hand, shows a dramatic increase over previous levels. The ion kinetic energy w_i, also shown in Fig. 6, increases by nearly 200% after $\omega_{pe}t = 300$. Like the electron case, the kinetic energy distribution is inhomogeneous in space and decreases away from the source (Fig. 7). However, unlike the situation for electrons, the energy gain for the ions was mostly due to an increase in velocity in the $\hat{x}$ direction, perpendicular to the magnetic field. Furthermore, as shown in Fig. 8, energetic ion tails are formed in the ion velocity distribution $f_i(v_x)$. The reason for this difference in ion behavior is that the large perpendicular electric fields near the exciting structure (Fig. 5(b)) strongly accelerate the ions but do not affect the magnetized electrons. The magnetic field would eventually return the ions back to the exciter and they could be accelerated again.

IV. RESONANT OSCILLATIONS DRIVEN BY AN EXTERNAL SOURCE

In the previous section, non-resonant driven oscillations were observed to have generally low amplitudes inside the plasma. In this section, the enhanced plasma response when the external source excites a bounded plasma resonance is considered. One example is studied in detail, and particular attention is paid to the nonlinear evolution of the system and the space and velocity-space distribution of the plasma heating.

The dispersion relation of the bounded plasma slab, based on a warm electron-cold ion fluid model was calculated[17] and is illustrated in Fig. 9. Here the frequency is plotted as a function of the parallel wavenumber and each curve corresponds to different allowable perpendicular wavenumbers. The frequency ($\omega_o = 2.3\ \omega_{pi}$) and length of two phased capacitor plates was chosen so that the wavenumber spectrum peaks at a normal mode (point A in Fig. 9) whose parallel phase velocity is about 6 v_{th}, and thus there would be little electron heating initially by Landau damping. The source strength was chosen to be $w = 1$.

The computer plasma was followed for 27 oscillation periods. The time evolution of the electric field energy, illustrated in Fig. 10, shows the secular resonant growth followed by absorption of the wave energy. Then somewhat later, the process repeats. The external source, whose amplitude is indicated by the arrow in Fig. 10, was kept on during the entire run. Examination of the evolution of the total kinetic energy of each species, illustrated in Fig. 11, shows that the energy absorption is dominated by electrons.

A. Electron Dynamics

The rate of increase of the electron kinetic energy and the amplitude of the electric field energy are found to be closely correlated, both reaching their maximum value at $\omega_{pe}t = 85$ and their minimum value at

$\omega_{pe}t = 130$. By examining the electron velocity distribution function, one finds that the increase in kinetic energy is entirely due to electrons quickly being accelerated to large velocities along the $\hat{z}$ direction, as shown in Fig. 12. One can see that electrons having velocities as large as 10 v_{th} (that is, with 100 times the thermal energy) are created by $\omega_{pe}t = 220$. This process continues until the resonant wave has lost most of its energy.

This behavior can be understood in terms of the concept of particle trapping. Initially there were no electrons moving close enough to the phase velocity of the wave to be trapped. As the potential ϕ_o grows in magnitude, a few particles can satisfy the trapping criterion

$$v > \frac{\omega}{k} - 2\sqrt{\frac{e\phi_o}{m_e}} \tag{5}$$

When this happens, the wave accelerates the particles and loses some energy. If the wave damping is small, the wave will regain this energy when the trapped particles are later decelerated by the wave. However, if many particles are suddenly accelerated, the wave may lose so much energy that it can no longer trap the particles, and the result is the generation of fast particles accompanied by the decay of the wave. Tail formation was observed to occur in the simulation when

$$\frac{\omega}{k} - 2\sqrt{\frac{e\phi_o}{m_e}} \approx 2.5\ v_{th} \tag{6}$$

indicating that this acceleration process occurred when the wave amplitude was large enough to begin to trap particles in the bulk of the electron velocity distribution. A similar mechanism has been discussed by Dawson and Shanny.[18]

A significant feature of the interaction of the electrons with the wave is that the interaction is localized in space because the eigenmode (not shown) has large parallel electric fields near the boundaries. Since the electrons are tightly bound to the magnetic field lines, it is not the spatial distribution of the total electric field for the eigenmode but rather the distribution of the parallel electric field which is important in accelerating the electrons, even though the magnitude of the parallel electric field is small compared to the perpendicular electric field. A graph of the electron kinetic energy versus position in the perpendicular direction, Fig. 13, shows that the kinetic energy profile in space follows approximately the same pattern as the parallel electric field energy for the eigenmode (not shown).

These results illustrate a possible method for controlling the electron temperature profile in a bounded plasma by exciting eigenmodes whose wavelengths are comparable to the plasma width. Specifically, since a bounded plasma mode is determined by the plasma parameters and geometry, one can obtain a desired temperature profile if a mode with appropriate parallel electric field distribution is chosen. For the case illustrated in Fig. 13, about equal electron heating on both sides of the plasma was obtained, even though the exciter was only on one boundary. Of course, only the parallel energy is increased.

B. Ion Dynamics

The ions do not gain much energy from the resonant wave, as one can see from Fig. 11. The phase velocity of the excited wave is too fast to resonate directly with the ions, and except for the increase of oscillation energy evident in Fig. 11, the ions can only gain energy in a nonlinear fashion. The key to understanding the behavior of the ions turns out to be the ponderomotive force on the electrons and the resulting density depressions. Furthermore, by

understanding the ion behavior the reason for the second increase in wave amplitude, shown in Fig. 10, becomes clear.

Since the normal mode being excited has a strong spatial distribution of electric field energy, the electrons feel a large ponderomotive force. The largest component for electrons is due to the parallel gradients of the parallel electric field energy.[6] For ions the ponderomotive force is negligibly small. The electrons are therefore pushed away from regions of large parallel electric field, and the resulting charge imbalance gives rise to an ambi-polar potential which forces electrons and ions out of the high field regions together, leaving a density depression.

Ions streaming away from the high field regions are observed in the simulation beginning at $\omega_{pe}t = 100$, and there is a corresponding increase in ion kinetic energy (Fig. 11). The peak density depression occurs around $\omega_{pe}t = 240$, and a three-dimensional view of the density (for electrons) is shown in Fig. 14 (averaged over one oscillation period). The ion density looks similar, although somewhat noisier. This mechanism of ion heating has also been observed in recent experiments investigating the focus region of intense RF radiation above the lower hybrid frequency.[19] The electrons gain a negligible amount of energy in this manner compared with the energy they gain directly from the wave.

Because the system is periodic in the $\hat{z}$ direction, ions from adjacent high field regions accumulate between these regions, until a potential develops that opposes further ion build-up. Shortly after, around $\omega_{pe}t = 240$, the ion kinetic energy shows another jump because even though some ions are slowed by this potential, others are accelerated even more. Thus a slowly-varying potential modulates the ion heating, and this shows up as undulations in Fig. 11. This type of ion heating resulted in fast tails in the parallel velocity distribution for ions, with ions having velocities as large as 5 or 6 times the background ion thermal velocity.

C. Relaxation Oscillations

When the plasma density relaxes to a nearly homogeneous state (although fluctuations have increased), around $\omega_{pe}t = 350$, the electric field returns to resonant growth. This recurrence can be described by the term relaxation oscillation. Although the external source has been on all this time, the plasma density had changed so much that the source was no longer coupling to a resonant mode. But when the density finally relaxes, a resonant mode can be excited again. The whole process we have been describing repeats itself, although the growth this time is not so rapid, since there are now particles traveling fast enough to interact with the wave.

Although in the example we have been studying, it has been the sudden acceleration of electrons which damped the resonant wave, it is conceivable that with different parameters (such as a resonant mode with a higher parallel phase velocity), the density modification could have "detuned" the resonance first, in which case the evolution of the plasma heating could have been quite different. This possibility needs further study, because it might lead to larger ion heating.

The plasma state at the end of the computer run has several times larger fluctuations of density and electric field than thermal level. Frequency analysis indicates that parametric decay to other modes was not significant; for the two dimensional geometry chosen, however, such decay was not expected.

V. SUMMARY

Summarizing the results for the non-resonant driven oscillations at frequencies above the lower hybrid, the plasma response in the interior is relatively small. At the surface, the plasma response is dominated by electrons. Resonance cones can be excited in this model at certain frequencies. In all cases a large potential drop near the exciter was observed due to the presence of a plasma sheath. Modulation of the source at ion cyclotron harmonics by the plasma was also observed. The plasma surface acts as a filter, absorbing those wavenumbers whose phase velocities fall in the electron velocity distribution. Most of the plasma heating occurs at the surface and takes the form of an increase of electron velocity parallel to the magnetic field but without the creation of fast tails in the velocity distribution. Ions were appreciably heated only for relatively large amplitude exciters by being accelerated away from the source.

The results for the resonant driven oscillations can be described as initial growth followed by relaxation oscillations. The evolution of the energy is dominated by electrons. The resonance is quenched by sudden tail formation and resultant wave damping. Electron heating is localized in space and follows the pattern of the parallel electric field energy for the resonant mode. This offers a possibility for controlling the electron temperature profile in space by excitation of bounded plasma resonances. Nonlinear density changes associated with the ponderomotive force are significant. Ions gain energy by being expelled from the density cavities by the ambi-polar potential associated with the ponderomotive force, as observed in recent experiments. When the density relaxes, the resonant mode is excited again, and the process repeats.

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REFERENCES

1. T. H. Stix, Phys. Rev. Lett. 15, 878 (1965).
2. V. E. Golant, Zh. Tekh. Fiz. 41, 2492 (1971) [Sov. Phys.-Tech. Phys. 16, 1980 (1972)].
3. G. J. Morales, Phys. Fluids 20, 1164 (1977).
4. R. F. Fisher and R. W. Gould, Phys. Fluids 14, 857 (1971).
5. P. M. Bellan and M. Porkolab, Phys. Fluids 19, 995 (1976).
6. G. J. Morales and Y. C. Lee, Phys. Rev. Lett. 35, 930 (1975).
7. R. L. Stenzel and W. Gekelman, Phys. Fluids 20, 108 (1977).
8. V. E. Golant and A. D. Piliya, Usp. Fiz. Nauk 104, 413 (1971) [Sov. Phys.-Usp. 14, 413 (1972)].
9. J. M. Kindel, H. Okuda, and J.M. Dawson, Phys. Rev. Lett. 29, 995 (1972).
10. M. Porkolab, Phys. Fluids 17, 1432 (1974).
11. A. Hasegawa and L. Chen, Phys. Fluids 18, 1321 (1975).
12. C. Chu and J. M. Dawson, Phys. Fluids 19, 981 (1976).
13. M. Brambilla, Plasma Phys. 18, 669 (1976).
14. M. Porkolab, S. Bernabei, W. M. Hooke, R. W. Motley, and T. Nagashima, Phys. Rev. Lett. 38, 230 (1977).
15. V. K. Decyk and J. M. Dawson, UCLA Center for Plasma Physics and Fusion Engineering Report PPG-331 (1977). To be published.
16. C. C. Cheng and E. G. Harris, Phys. Fluids 12, 1262 (1969).
17. Viktor K. Decyk, Ph. D. dissertation, UCLA (1977).
18. J. M. Dawson and R. Shanny, Phys. Fluids 11, 1506 (1968).
19. W. Gekelman and R. L. Stenzel, Phys. Fluids 20, 1316 (1977).

FIGURES

FIG. 1 Electrostatic potential associated with lower hybrid resonance cones excited by point source. ($\Omega_e/\omega_{pe} = 1$, $M_i/m_e = 64$, $T_e/T_i = 10$, $\omega_o/\omega_{pe} = .35$, $w = 2/3$, $2 \times 42 \times 192$ particles, 32×128 grid, particle size $a_x = a_z = 1$, $\tilde{\lambda}_{De} = 1$)

FIG. 2 Time evolution of the total electric field energy for a point source exciter.

FIG. 3 Time evolution of the scaled electron (w_e) and ion (w_i) kinetic energies for a point source exciter.

FIG. 4 Equipotential lines for:

(a) short capacitor plates in vacuum;

(b) oscillations driven by short capacitor plates as observed in simulation; ($\Omega_e/\omega_{pe} = 1$, $M_i/m_e = 64$, $T_e/T_i = 1$, $\omega_o/\omega_{pe} = .25$, $w = 4/3$, $2 \times 42 \times 192$ particles, 32×128 grid, particle size $a_x = a_z = 1$, $\tilde{\lambda}_{De} = 1$);

(c) oscillations driven by short capacitor plates as predicted by fluid model.

FIG. 5 Equipotential lines for:

(a) phased array of capacitor plates in vacuum;

(b) oscillations driven by phased array of capacitor plates as observed in simulation; ($\Omega_e/\omega_{pe} = 1$, $M_i/m_e = 64$, $T_e/T_i = 10$, $\omega_o/\omega_{pe} = .25$, $w = 10$, $2 \times 42 \times 192$ particles, 32×128 grid, particle size $a_x = a_z = 1$, $\tilde{\lambda}_{De} = 1$).

FIG. 6 Time evolution of scaled electron (w_e) and ion (w_i) kinetic energies for a phased array of capacitor plates.

FIG. 7 Spatial dependence of the scaled electron (w_e) and ion (w_i) kinetic energies perpendicular to the magnetic field (source is at $x = 0$).

FIG. 8 Ion velocity distribution perpendicular to the magnetic field, averaged over all space. Dashed curve corresponds to initial distribution and solid curve to final distribution.

FIG. 9 Calculated dispersion relation for a plasma slab with cold ions and $L_x/\lambda_{De} = 32$.

FIG. 10 Time evolution of the electric field energy for the resonantly driven case. Arrow indicates energy of exciter. ($\Omega_e/\omega_{pe} = 1$, $M_i/m_e = 64$, $T_e/T_i = 10$, $\omega_o/\omega_{pe} = .28$, $w = 1$, $2 \times 42 \times 192$ particles, 32×128 grid, particle size $a_x = a_z = 1$, $\tilde{\lambda}_{De} = 1$)

FIG. 11 Time evolution of the scaled electron (w_e) and ion (w_i) kinetic energies for the resonantly driven case.

FIG. 12 Electron velocity distribution parallel to the magnetic field, averaged over all space. Dashed curve corresponds to initial distribution and solid curve to distribution after wave damping.

FIG. 13 Spatial dependence of the electron kinetic energy perpendicular to the magnetic field. (Source is at $x = 0$.) Bottom curve shows energy dependence after first wave damping and top curve shows energy dependence after second wave damping.

FIG. 14 Electron density profile at peak density depression, averaged over one oscillation period.

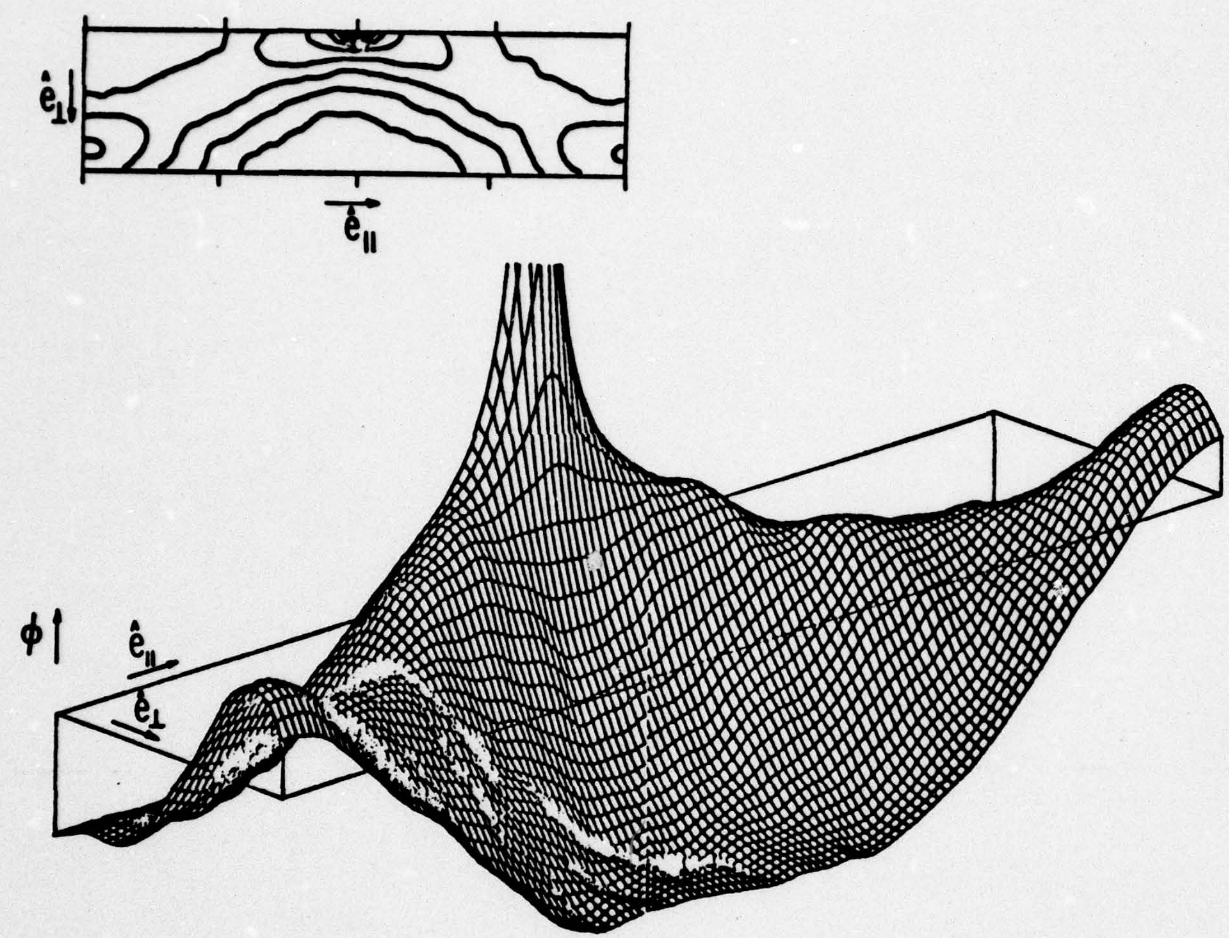


FIGURE 1

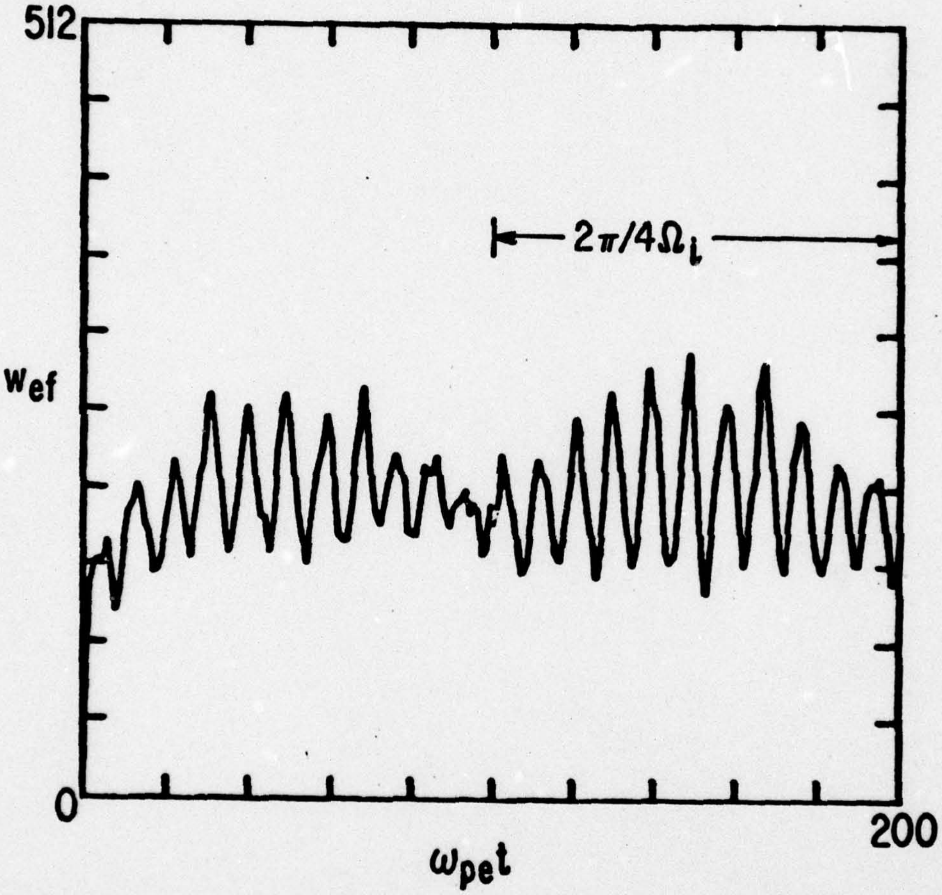


FIGURE 2

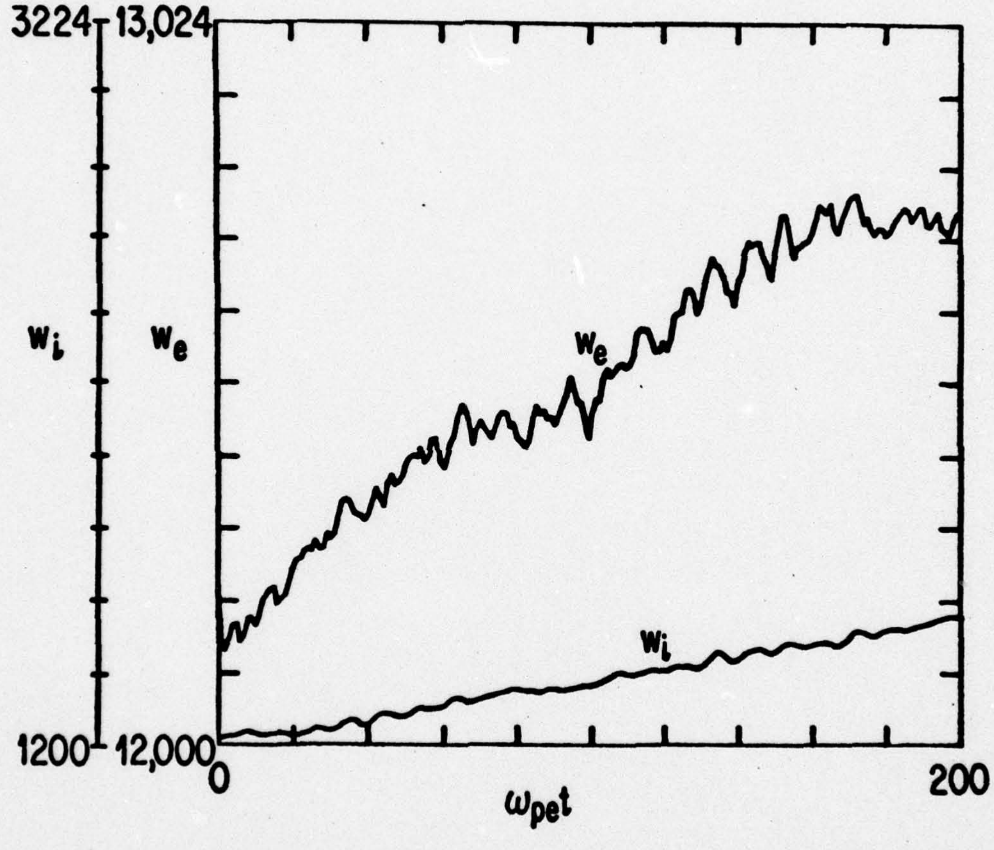


FIGURE 3

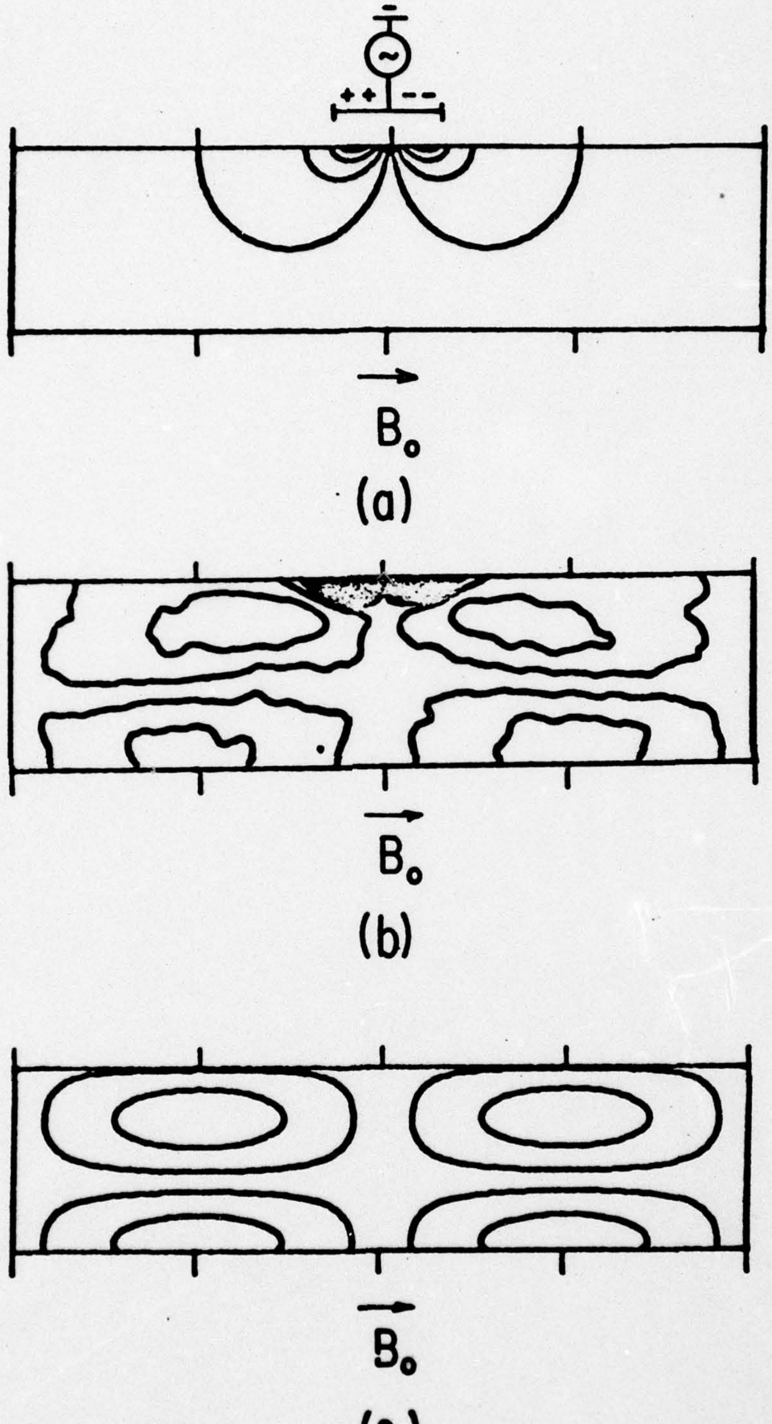
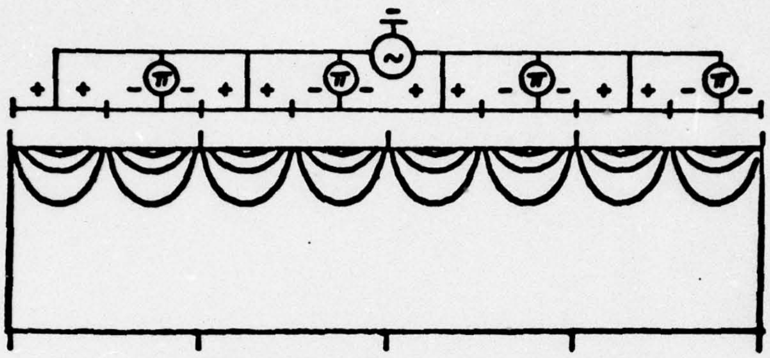
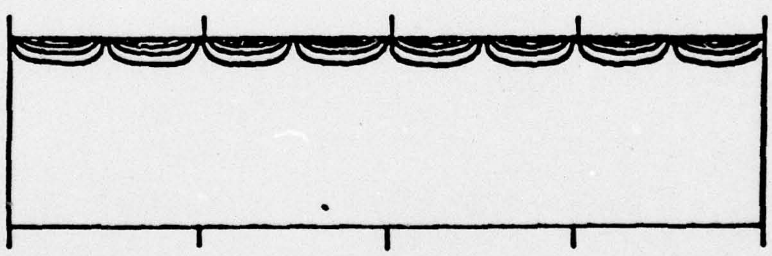


FIGURE 4



$\overrightarrow{B_o}$

(a)



$\overrightarrow{B_o}$

(b)

FIGURE 5

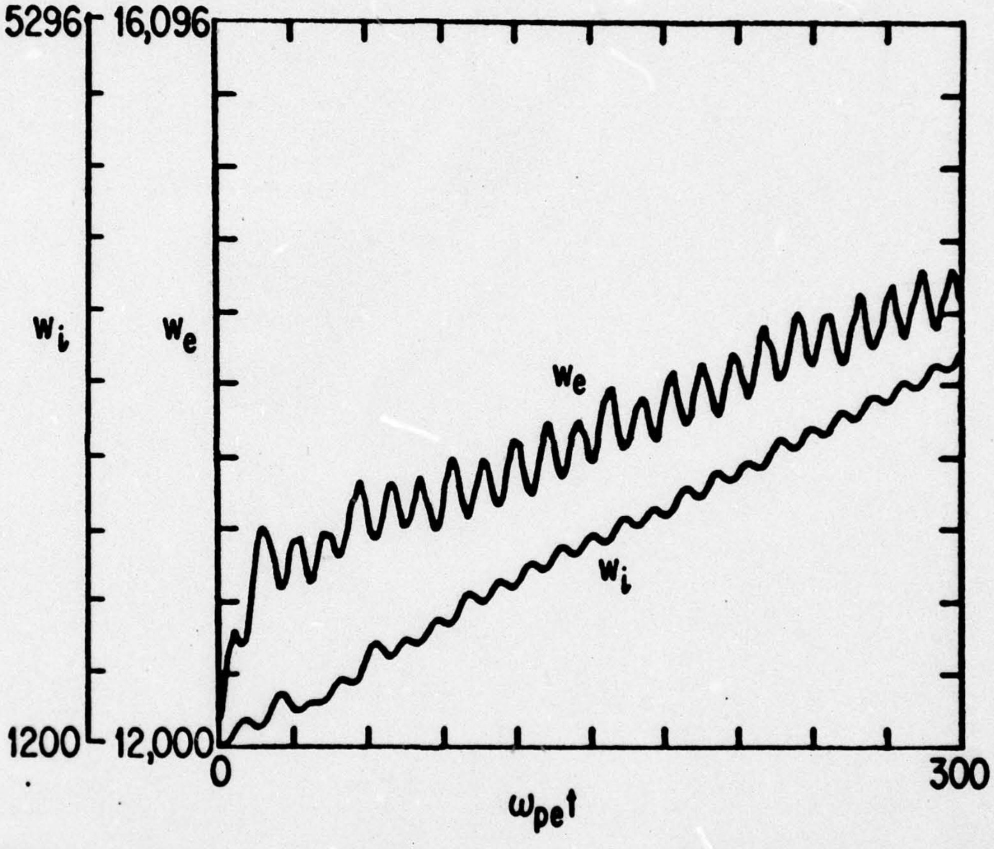


FIGURE 6

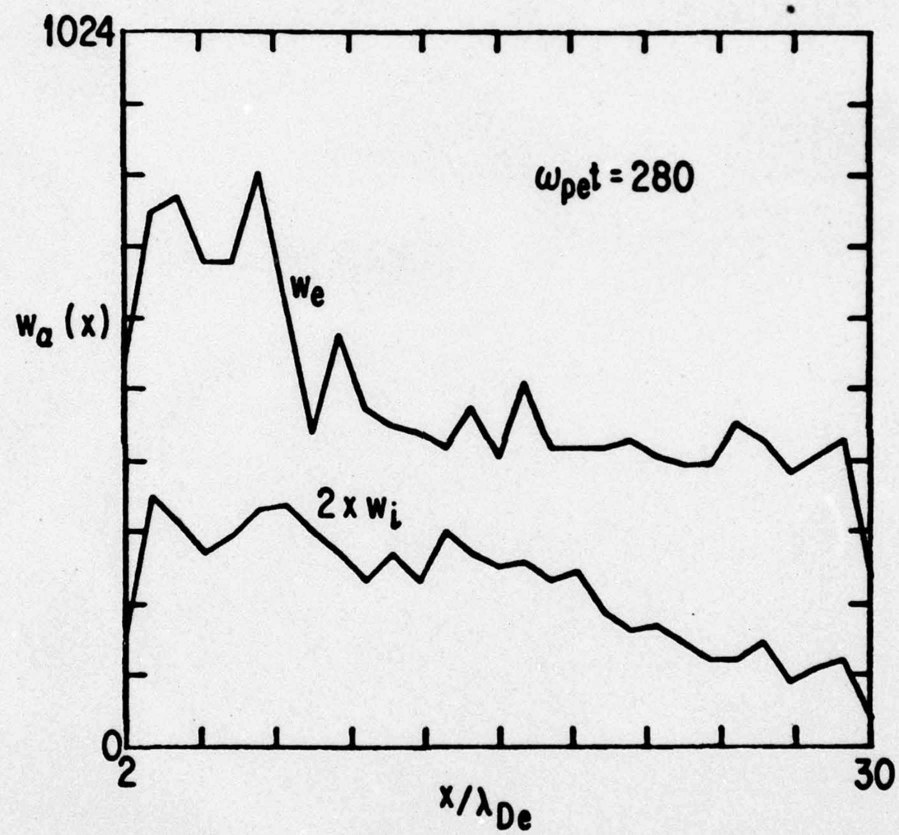


FIGURE 7

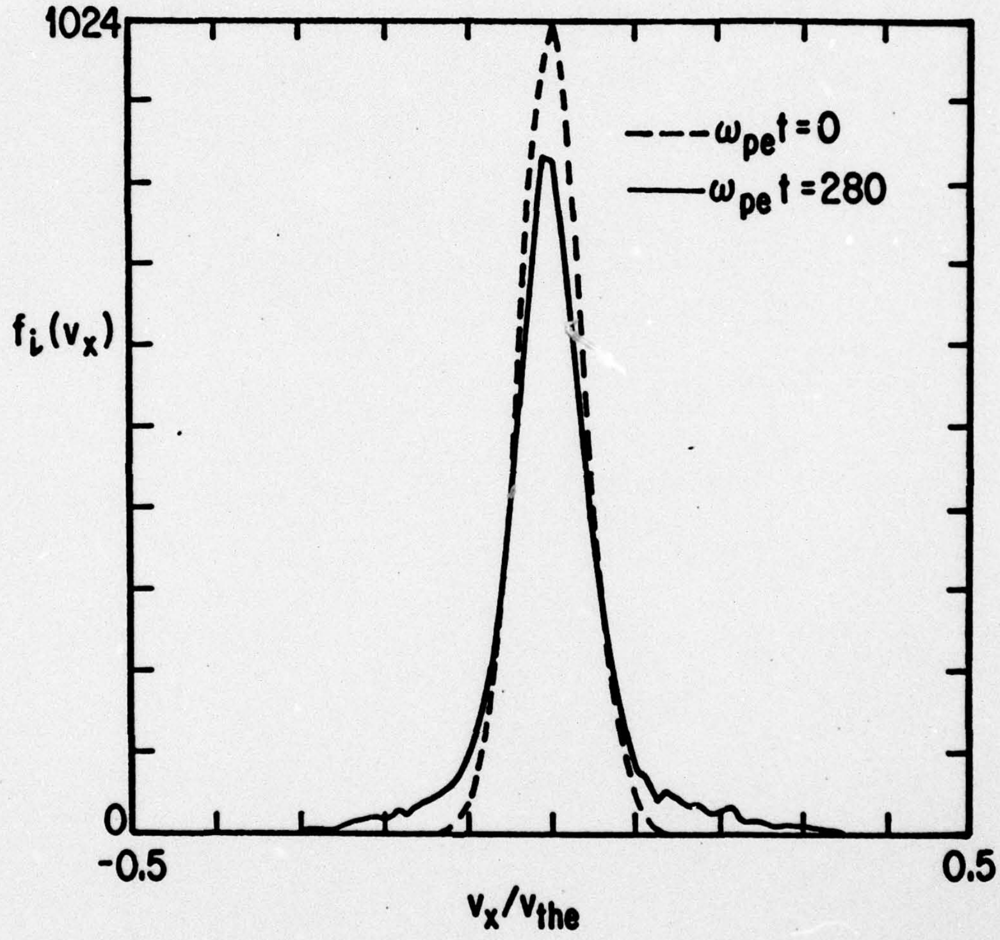


FIGURE 8

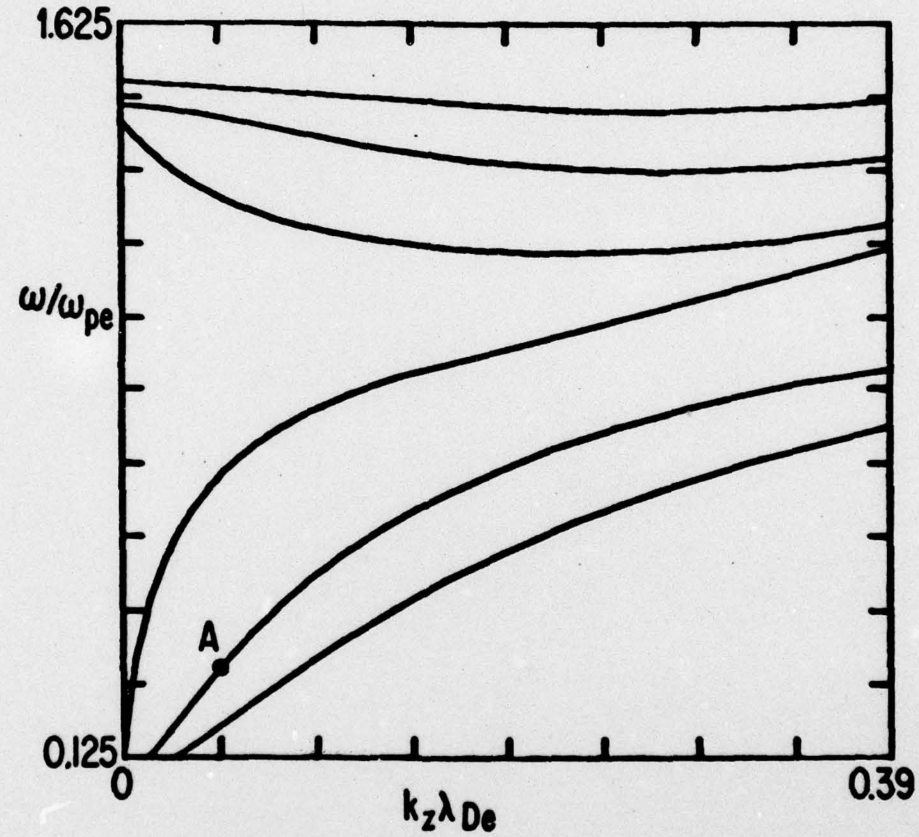


FIGURE 9

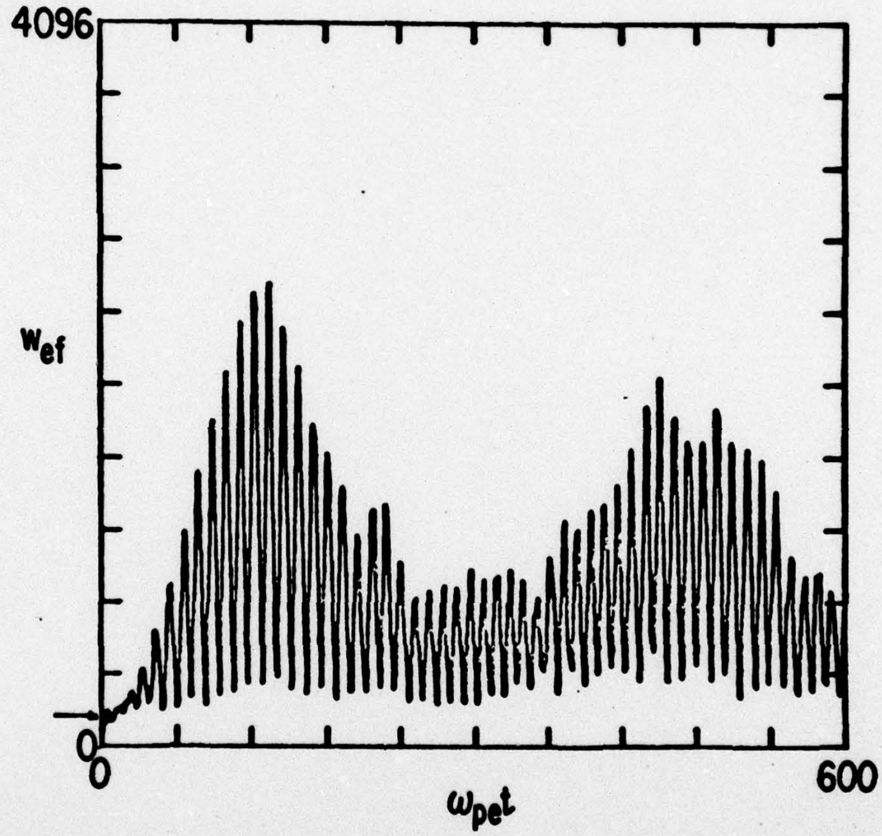


FIGURE 10

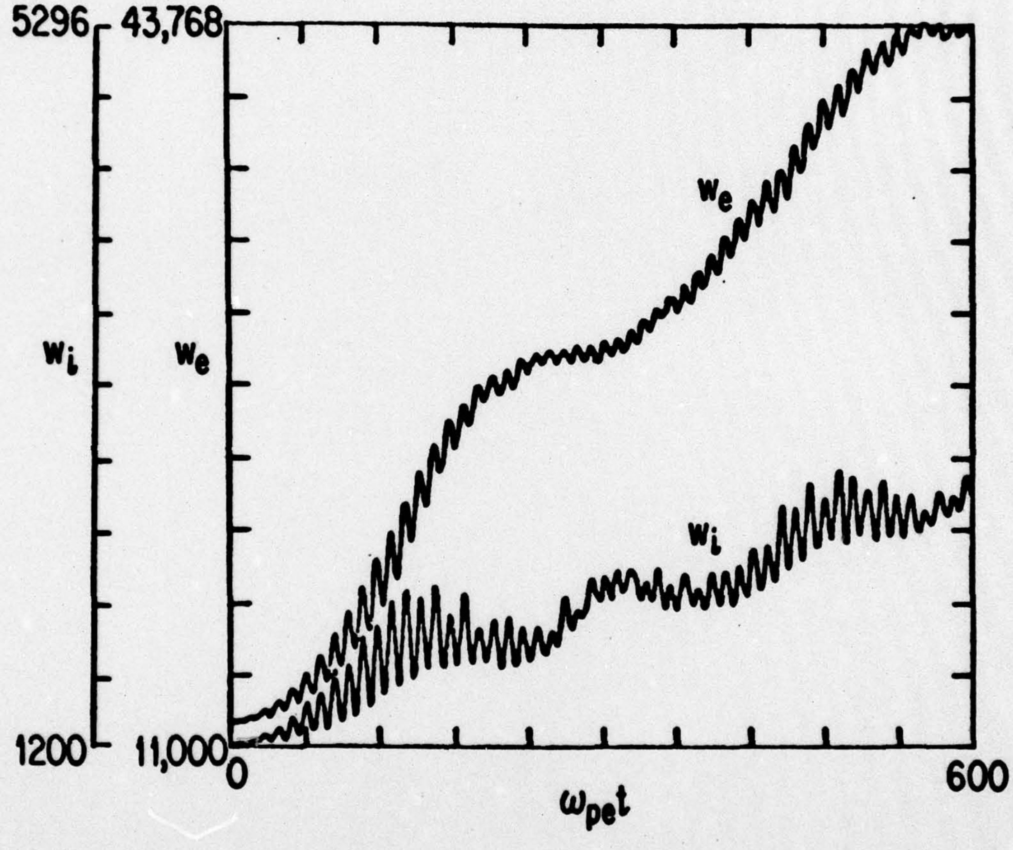


FIGURE 11

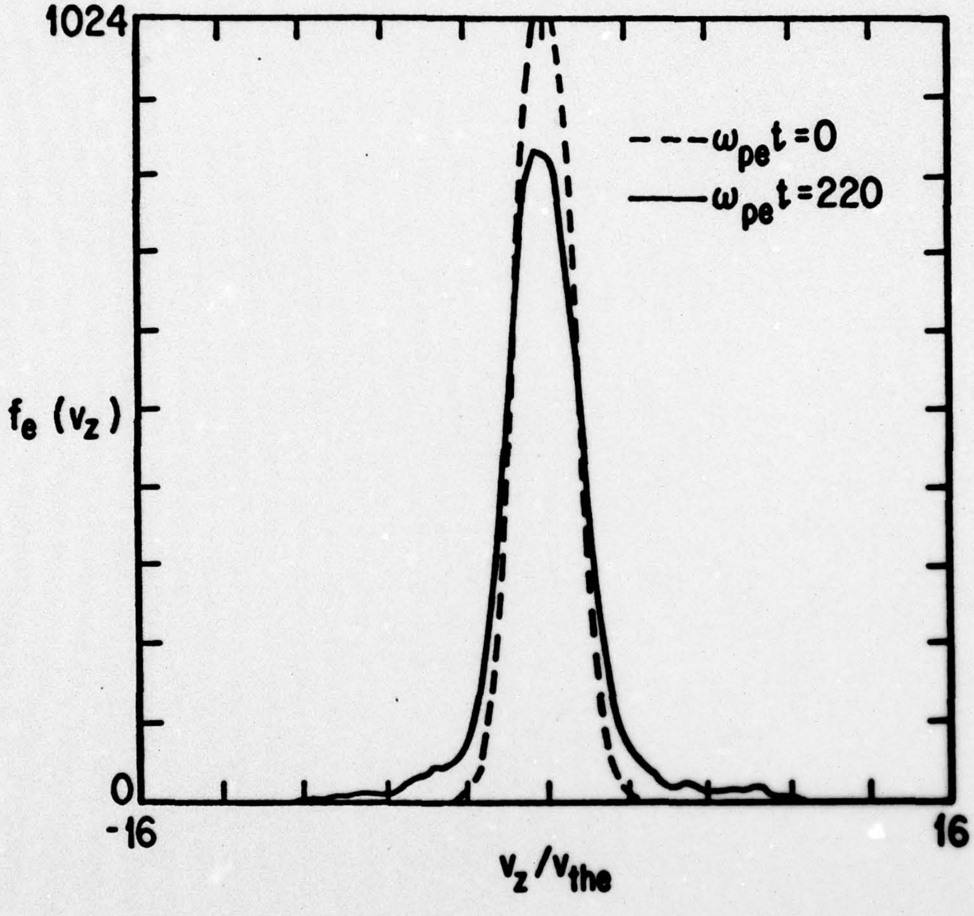


FIGURE 12

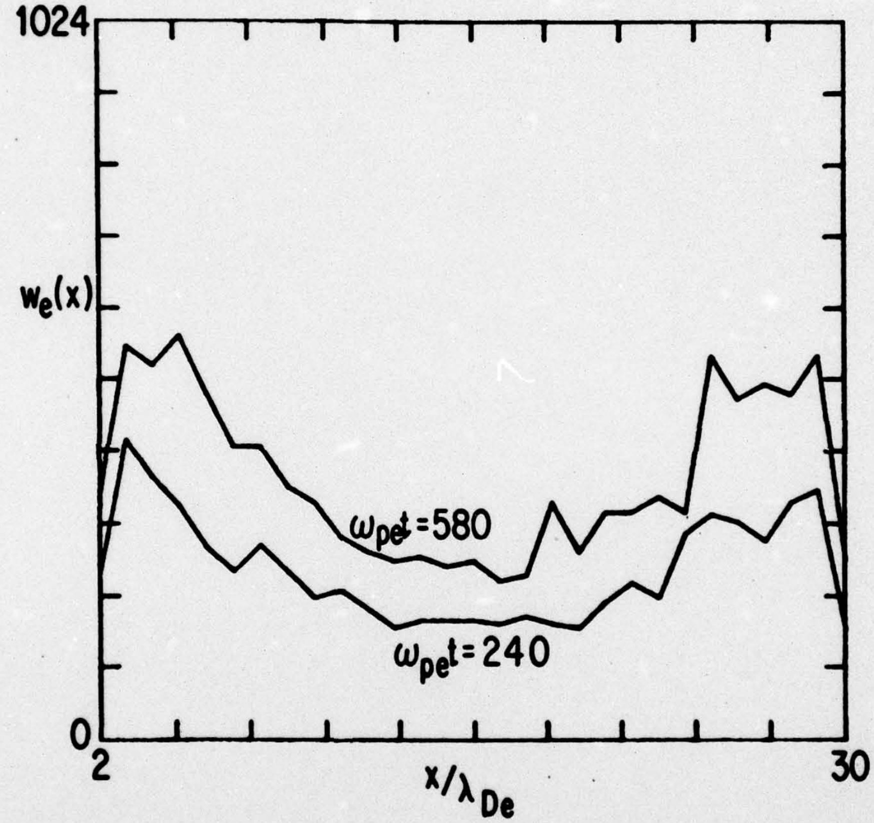
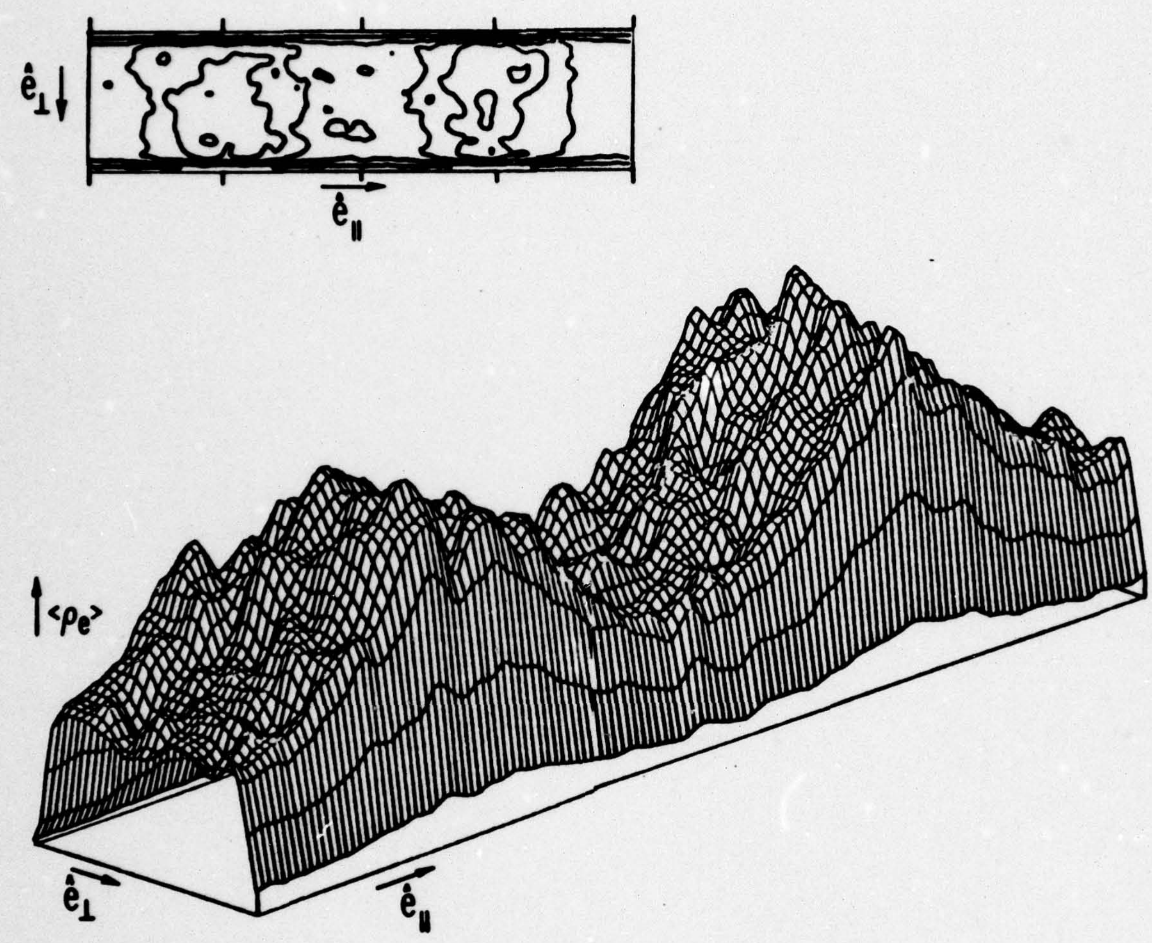


FIGURE 13



$\hat{e}_\perp$
$\hat{e}_\parallel$
$\langle \rho_e \rangle$
$\hat{e}_\perp$
$\hat{e}_\parallel$

FIGURE 14

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PPG-157 "Growth and Saturation of the Absolute Electron Cyclotron Drift Instability", Phys. Rev. Lett., 31, 1545 (1973)(R.L. Stenzel and B.H. Ripin).
PPG-158 "Parametric Instabilities of Electromagnetic Waves in Plasmas", Phys. Fluids 17, 778 (1974)(J. Drake, P.K. Kaw, Y.C. Lee G. Schmidt, C.S. Liu and M.N. Rosenbluth).
PPG-159 "Nonlinear Optics of Plasmas", Survey Lecture of Int'l. Congress on Waves and Instabilities in Plasmas, Innsbruck, Austr (1973) Institute for Theoretical Physics, Innsbruck, p. C1 (1973)(F.F. Chen).
PPG-160 "Physical Mechanisms for Laser and Plasma Heating - Parametric Instabilities", Laser Interaction and Related Plasma Phenomena, ed. H.J. Schwartz and H. Hora (Plenum Press) 3A, 291 (1974)(F.F. Chen).
PPG-161 "Trip Report - 6th European Conf. on Cont. Fusion and Plasma Phys., July 30-August 4, 1973", August (1973)(B.D. Fried).
PPG-162 "Abstracts presented at Philadelphia Meeting of Am. Phys. Soc., Div. Plasma Phys., October 31-November 3, 1973"
PPG-163 "Enhancement of Plasma DC Currents by Intense AC Fields", Phys. Fluids 17, 987 (1974)(A.T. Lin and J.M. Dawson).
PPG-164 "Temporal Electrostatic Instabilities in Inhomogeneous Plasmas", Phys. Rev. Lett., 32, 135 (1974)(Y.C. Lee and P.K. Kaw)
PPG-165 "Nonlinear Schrodinger Equation Model of Oscillating Two-Stream Instability", Phys. Rev. Lett., 32, 457 (1974)(G. Morales Y.C. Lee and R.B. White).
PPG-166 "Backscattering Decay Processes in Electron Beam-Plasma Interactions Including Ion Dynamics", Phys. Rev. Lett., 32, 406 (1974)(B.H. Quon, A.Y. Wong and B.H. Ripin).
PPG-167 "Conversion of Electromagnetic Waves to Electrostatic Waves in Inhomogeneous Plasmas", Phys. Rev. Lett., 32, 654 (1974) (R. Stenzel, A.Y. Wong and H.C. Kim).
PPG-168 "Langmuir Wave Turbulence - Condensation and Collapse", Comm. Plasma Phys. and Cont. Fusion (1974)(Y.C. Lee, C.S.LLiu and K. Nishikawa).
PPG-169 "The Consequences of Micropulsations on Geomagnetically Trapped Particles", Rev. Space Sci., 16, 443 (1974)(R.M. Thorne)
PPG-170 "Linear Wave Conversion in Inhomogeneous Plasmas", March (1974)(D.L. Kelly and A. Banos).
PPG-171 "The Cause of Storm After-Effects in the Middle Latitude D-Region Ionosphere", J. Atmospherica and Terrestrial Phys.(197 (W.N. Spjeldvik and R.M. Thorne).
PPG-172 "Application of an Electromagnetic Particle Simulation Code to the Generation of Electromagnetic Radiation", Phys. Fluid 17, 1995 (1974)(A.T. Lin, J.M. Dawson and H. Okuda).
PPG-173 "The Ponderomotive Force Exerted on a Plasma by an Infrared Laser Beam", Dissertation, March (1974)(M. Marhic).
PPG-174 "What we Have Learned from the Magnetosphere", Comments on Astrophys. and Space Phys., 6, 71 (1975)(C.F. Kennel).
PPG-175 "Observation of the Ponderomotive Force and Oscillating Two-Stream Instability", April (1974)(H.C. Kim, R. Stenzel and A.Y. Wong).
PPG-176 "Electron Beam Plasma Interaction Including Ion Dynamic", Dissertation, June (1974)(B.H. Quon).
PPG-177 "Linear Conversion and Parametric Instabilities in a Non-Uniform Plasma", Dissertation, June (1974)(H.C.Kim, R. Stenzel and A.Y. Wong).
PPG-178 "Stimulated Compton Scattering of Electromagnetic Waves in Plasma", Phys. Fluids 18, 201 (1975)(A.T. Lin and J.M. Dawson)
PPG-179 "Equatorial Spread F: Low Frequency Modes in a Collisional Plasma", Dissertation, July (1974)(M.K. Hudson).
PPG-180 "Effect of the Ponderomotive Force in the Interaction of a Capacitor RF Field with a Nonuniform Plasma", Phys. Rev. Lett 33, 1016 (1974)(G.J. Morales and Y.C. Lee).
PPG-181 "Deducation of Ionospheric Tidal Winds by Dynamo Simulation", August (1974)(J.P. Schieldge and S.V. Venkataswaran).
PPG-182 "Response of the Middle Latitude D-Region to Geomagnetic Storms", J. Atmos. and Terres. Phys. (1974)(W. Spjeldvik and R.M. Thorne).
PPG-183 "Production of Negative Ions and Gneration of Intense Neutral Beams", Applied Phys. Lett., 25, 579 (1974)(A.Y. Wong, J.M. Dawson and W. Gekelman).
PPG-184 "Development of Cavitons and Trapping of RF Fields", Phys. Rev. Lett., 33, 886 (1974)(H.C. Kim, R. Stenzel and A.Y. Wong)
PPG-185 "Albuquerque Abstracts: Papers presented at Albuquerque Meeting of Am. Phys. Soc., Div. Plasma Phys., Oct 28-31, 1974".
PPG-186 "Localized Quasi-Stationary Plasma Modes in One, Two and Three Dimensions", Phys. Rev. Lett. (1974)(J.Z. Wilcox and T.J. Wilcox).
PPG-187 "Denouement of Jovian Radiation Belt Theory", Proc. of Conf. on Magnetospheres of Earth and Jupiter, Frascati, Italy, May 28 - June 1 (1974)(F.V. Coroniti).
PPG-188 "Is Jupiter's Magnetosphere Like a Pulsar's or Earth's?" ibid, (C.F. Kennel and F.V. Coroniti).
PPG-189 "Parametric Instability of the Sheath Plasma Resonance", Radio Sci., 10, 485 (1974)(R. Stenzel, H.C. Kim and A.Y. Wong).
PPG-190 "Effect of Localized Electric Fields on Evolution of the Velocity Distribution Function", Phys. Rev. Lett., 33, 1534 (1974)(G.J. Morales and Y.C. Lee).
PPG-191 "Parametric Instabilities in Plasma", September (1974)(J.M. Dawson and A.T. Lin).
PPG-192 "Surmac - A Large Surface Magnetic Confinement Device", September (1974)(A.Y. Wong).
PPG-193 "Extraction of Energy from High Intensity Ion Beams", Presented at 2nd Symp. on Ion Sources and Formation of Ion Beams, Berkeley, October 22-25 (1974)(A.T. Forrester).
PPG-194 "A Large Quiescent Magnetized Plasma for Wave Studies", Rev. Sci. Instruc., 46, 1386 (1975)(W. Gekelman and R.L. Stenzel)
PPG-195 "Electrostatic Waves Near the Lower Hybrid Frequency", Phys. Rev. Lett., A11, 2075 (1975)(R.L. Stenzel and W. Gekelman).
PPG-196 "A Corrugated Mirro-Cyclotron Frequency Direct Conversion System (Comi-Cyfer)", IEEE Transactions on Plasma Sci., October (1974)(A.T. Forrester, J. Busnardo-Neto and J.T. Crow).
PPG-197 "The Study of Comparative Magnetospheres: The Future of Space Physics", Presented to NASA Study Group on "Outlook for Space", Goddard Space Flight Center, September (1974)(F.V. Coroniti and C.F. Kennel).
PPG-198 "Application of the Fokker-Planck Numerical Method to Anisotropic and Energy-Dependent Electron Precipitation", October (1974)(W. Spjeldvik).
PPG-199 "Self-focusing and Filamentation of Laser Light in Plasmas", Proc. of IAEA Sixth Conf. on Plasma Phys., Tokyo, November (1974)(Y.C. Lee, C.S. Liu, H.H. Chen and K. Nishikawa).
PPG-200 "Stimulated Brillouin Backscatter in the Equatorial Electrojet", November (1974)(D.D. Barbosa and C.F. Kennel).
PPG-201 "The Electromagnetic Interchange Mode in a Partially Ionized Collisional Plasma", J. Plasma Phys., 14, 121 (1975)(M.K. Hudson and C.F. Kennel).
PPG-202 "The Collisional Drift Mode in a Partially Ionized Plasma", J. Plasma Phys., 14, 135 (1975)(M.K. Hudson and C.F. Kennel).
PPG-203 "High Density Constraint on the Entropy Instability", December (1974)(M.K. Hudson and C.F. Kennel).
PPG-204 "Excitation of Zero-Frequency Instabilities and Spatial Collapse of Beam Driven Plasma Waves", Phys. Rev. Lett., 34, 1499 (1975)(A.Y. Wong and B.H. Quon).
PPG-205 "A Recursive Numerical Method to Solve the Pure Pitch Angle Diffusion Equation", December (1974)(W.N. Spjeldvik).
PPG-206 "The Equilibrium Radiation Belt Electron Pitch Angle DIstribution and Its Dependence on the Radial Diffusive Source", January (1975)(W.N. Spjeldvik).
PPG-207 "Optimization of Plasma Confinement with Permanent Magnet Multipoles", (1975)(K.N. Leung, T.K. Samec and A. Lamm).
PPG-208 "Anomalous Electron Transport and Lower-Hybrid Wave Damping", Phys. Fluids 18, 1762 (1975)(C. Chu, J.M. Dawson and H.Okud
PPG-209 "Plasma Confinement by a Picket-Fence", January (1975)(K.N. Leung, N. Hershkowitz and T. Romesser).
PPG-210 "Secular Mode Coupling and Anomalous Drag: A Theory of Plasma Turbulence with Application to the Electron Beam-Plasma Instability", Dissertation, February (1975)(J. Drake).
PPG-211 "Nonlinear Generation of Intense Localized Electric Fields in Plasmas", February (1975)(G.J. Morales and Y.C. Lee).
PPG-212 "Plasma Electron Heating by Injection of Low Energy Electrons", February (1975)(N. Hershkowitz and K.N. Leung).
PPG-213 "Ion Confinement by Electrostatic Potential Well in Magnetic Multiple Device", Phys. Lett., 53A, 85 (1975)(Y. Nakamura, B.H. Quon and A.Y. Wong).
PPG-214 "Scattering of Electromagnetic Waves into Plasma Oscillations via Plasma Particles", Phys. Fluids 18, 1542 (1975)(A.T. Lin and J.M. Dawson).
PPG-215 "Surface Magnetic Confinement", Phys. Rev. Lett., 35, 1156 (1975)(A.Y. Wong, Y. Nakamura and B.H. Quon).
PPG-216 "Experimental Facilities of Plasma Physics Research Laboratories at UCLA", March (1975).
PPG-217 "A Modified Surmac Configuration", March (1975)(A.T. Forrester).
PPG-218 "Some New Ideas on Wet Wood Burners", accepted by Phys. Rev. Lett., July (1976)(J.M. Dawson and A.T. Lin).
PPG-219 "Plasma Heating at Frequencies Near the Lower Hybrid", April (1975)(C. Chu, J.M. Dawson and H. Okuda).
PPG-220 "Unstable High Frequency Electrostatic Modes Induced by a Loss Cone Distribution of Electorns", (1975)(B.D. Fried and D. Baldwin).
PPG-221 "ICRH Heating of a Magnetized Plasma and Associated Longitudinal Cooling", Phys. Rev. Lett., 36, 28 (1976)(J. Busnardo-Neto, J.M. Dawson, T. Kamimura and A.T. Lin).
PPG-222 "Plasma Confinement by Localized Magnetic Cusps", Dissertation, Mary (1975)(K. Leung).
PPG-223 "The Generation of Spiky Turbulence", accepted by Phys. Fluids, (1976)(G.J. Morales and Y.C. Lee).
PPG-224 "A Multipole Containment-Single Grid Extraction Ion Source", (1975)(A.T. Forrester, J.T. Crow, N.A. Massie and D.M. Goebe
PPG-225 "Q-Machines - by Robert W. Motley", A book review by F.F. Chen.
PPG-226 "Plasma Leakage Through a Low Beta Line Cusp", (1975)(N. Hershkowitz, K.N. Leung and T. Romesser).
PPG-227 "Localized Fields and Density Perturbations in Nonlinear Lower Hybrid Waves", Phys. Rev. Lett., 35, 1708 (1975)(W. Gekelman and R.L. Stenzel).
PPG-228 "Effect of Mirroring on Convective Transport in Plasmas", Phys. Rev. Lett., 36, 313 (1976)(T. Kamimura and J.M. Dawson).
PPG-229 "Parametric Excitation of Ion Fluctuations in the Relativistic Beam-Plasma Interaction", accepted by Phys. Fluids (1976) (H. Schamel, Y.C. Lee and G.J. Morales).
PPG-230 "UCLA Plasma Physics and Controlled Fusion Research, Presented for ERDA Program Review", July (1975)(B.D. Fried, J.M. Dawson, A.Y. Wong, T. Forrester and F.F. Chen).
PPG-231 "The Nonlinear Filamentation of Lower-Hybrid Cones", Phys. Rev. Lett., 35, 930 (1975)(G.J. Morales and Y.C. Lee).
PPG-232 "Fusion Reactor with Picket Fence Walls", submitted to Nuc. Fusion, (1976)(N. Hershkowitz and J.M. Dawson).
PPG-233 "Shock Formation in Large Amplitude Waves Due to Relativistic Electron Mass Variation", Phys. Rev. Lett., 36, 196 (1976) (J.F. Drake, Y.C. Lee, K. Nishikawa and N.L. Tsintsadze).
PPG-234 "Characteristics of a Large Volume RF Grid Discharge Plasma", (1975)(R. Schumacher, N. Hershkowitz and K.R. MacKenzie).
PPG-235 "Surface Magnetic Confinement; a Review", July (1975)(A.Y. Wong).
PPG-237 "St. Petersburg Abstract: Papers to be presented at St. Petersburg Meeting of Am. Phys. Soc. Div. Plasma Phys., Nov 1975"
PPG-238 "Parametric Instabilities in Strongly Relativistic, Plane Polarized Electromagnetic Waves", Phys. Rev. Lett., 36, 31 (1976)(J.F. Drake, Y.C. Lee and N.L. Tsintsadze).
PPG-239 "Detection of Buillouin Backscattering in Underdense Plasmas", (1975)(J. Turecheck and F.F. Chen).
PPG-240 "Adiabatic Invariance and Charged Particle Confinement in a Geometric Mirror", Phys. Rev. Lett., 35, 1763 (1975)(T.K. Samec, Y.C. Lee and B.D. Fried).
PPG-241 "Magnetic Fields for Surface Containment of Plasmas", accepted by J. Applied Phys. (1976)(A.T. Forrester and J.Busnardo-Neto)
PPG-242 "Electrostatic Parametric Instabilities Arising from Relativistic Electron Mass Oscillations", accepted by Phys. Fluids (1976)(A.T. Lin and N.L. Tsintsadze).
PPG-243 "Relativistic Nonlinear Plasma Waves in a Magnetic Field", accepted by J. Plasma Phys., (1976)(C.F. Kennel and R. Pellat)
PPG-244 "Flux Limits on Cosmic Acceleration by Strong Spherical Pulsar Waves", Astron. and Astrophys., 44, 31 (1975)(E. Asseo, C.F. Kennel and R. Pellat).
PPG-245 "On the Detection of Magnetospheric Radio Bursts from Uranus and Neptune", accepted by Nature (1976)(C.F. Kennel and J.E. Maggs).

PPG-246 "Parametric Instabilities with Finite Wavelength Pump", B.D. Fried, T. Ikemura, K. Nishikawa, and G. Schmidt, Phys. of Fluids, 19, 1975 (1976).

PPG-247 "The Scattering of Cosmic Rays by Magnetic Bubbles", R.F. Flewelling & F.V. Coroniti, Astrophys. J., 205, 135 (1976).

PPG-248 "Plasma Simulation on the CHI Microprocessor System", T. Kamimura, J.M. Dawson, B. Rosen, G.J. Culler, R.D. Levee and G. Ball., (1975).

PPG-249 "Nonlinear Interactions of Focused Resonance Cone Fields with Plasmas", R. Stenzel and W. Gekelman, Phys. Fluids 20, 108 (1977).

PPG-250 "The Effect of Pump Cutoff on Parametric Instabilities in an Inhomogeneous Plasma", J. VanDam and Y.C. Lee, (1976).

PPG-251 "Parametric Excitation of Ion Density Fluctuations in the Relativistic Beam-Plasma Interaction", H. Schamel, Y.C. Lee, & G.J. Morales, Phys. Fluids 19, 849 (1976).

PPG-252 "The Spiky Turbulence Generated by a Propagating Electrostatic Wave of Finite Spatial Extent", G.J. Morales, & Y.C. Lee, Phys. Fluids 19, 690 (1976).

PPG-253 "Departures from Theory of the Experimental Line Profile of Helium I 4471.5A", J. Turechek, January (1976).

PPG-254 "Maintenance of the Middle Latitude Nocturnal D-Layer by Energetic Electron Precipitation", W. Spjeldvik & R. Thorne, Pure and Applied Geophys. 114, 497 (1976).

PPG-255 "Free Boundaries for Plasmas in Surface Magnetic Field Configurations", B.D. Fried, J.W. VanDam & Y.C. Lee, Phys. of Fluids, 19, 1909 (1976).

PPG-256 "Soliton-Like Structures in Plasmas", Y.C. Lee and G.J. Morales, March (1976). To appear in Rocky Mtn. Math. Jr.

PPG-257 "Magnetic Field Reconnection in a Collisionless Plasma", F.V. Coroniti and A. Eviatar, Astrophys. J. Supp. 33, 189 (1977).

PPG-258 "The Earth's Magnetosphere", F.V. Coroniti, Accepted by Ency. of Phys. (1976).

PPG-259 "Lossy Radial Diffusion of Relativistic Jovian Electrons", D.D. Barbosa and F.V. Coroniti, J. Geophys. Res. 81, 4553 (1976).

PPG-260 "Relativistic Electrons and Whistlers in Jupiter's Magnetosphere", D.D. Barbosa and F.V. Coroniti, J. Geophys. Res. 81, 4531 (1976).

PPG-261 "A Self-Consistent Magnetostatic Particle Code for Numerical Simulation of Plasmas", J. Busnardo-Neto, P.L. Pritchett, A.T. Lin & J.M. Dawson, J. Comp. Phys. 23, 300 (1977).

PPG-262 "Relativistic Effects in Resonance Absorption", J.F. Drake and Y.C. Lee, Phys. of Fluids 19, 1772 (1976).

PPG-263 "Convective Electron Loss Cone Instabilities", M. Ashour-Abdalla and C.F. Kennel. Submitted to J. Geophys. Res. (1976).

PPG-264 "Experiments on Parametric Instabilities in Laser-Beam Plasma Interactions", R. Chen, Presented at Nobel Symposium.

PPG-265 "The Local Time Variation of ELF Emissions During Periods of Substorm Activity", R.M. Thorne, F.R. Church, W.J. Malloy, B.T. Tsurutani, J. of Geophys. Res., 82, 1585 (1977).

PPG-266 "An Investigation of Relativistic Electron Precipitation Events and their Association with Magnetospheric Substorm Activity", R.M. Thorne and T.R. Larsen, J. of Geophys. Res. 81, 5501 (1976).

PPG-267 "The Free Electron Laser", T. Kwan, J.M. Dawson & A.T. Lin, Phys. Fluids 20, 581 (1977).

PPG-268 "Stimulated Compton Scattering of Electromagnetic Waves off Plasma Ions", A.T. Lin and J.M. Dawson, Phys. Fluids 20, 538 (1977).

PPG-269 "Stability of Shell Distributions", D.D. Barbosa, Submitted to Planetary and Space Sciences, July (1976).

PPG-270 "Synchro-Compton Radiation Damping of Relativistically Strong Plasma Waves", C.F. Kennel, E. Asseo and R. Pellat, Submitted to Astronomy and Astrophysics, July (1976).

PPG-271 "Particle and Wave Dynamics in a Magnetized Plasma Subject to High RF Pressure", W. Gekelman & R.L. Stenzel, Phys. Fluids 20, 1316 (1977).

PPG-272 "Energetic Radiation Belt Electron Precipitation; A Natural Depletion Mechanism for Stratospheric Ozone, R.M. Thorne, Science, 195, 287 (1977).

PPG-273 "CTR Using the P-^{11}B Reaction", J.M. Dawson, August (1976).

PPG-274 "San Francisco Abstracts - Papers to be Presented at San Francisco Meeting of the American Physical Society Division of Plasma Physics, November 15-19 (1976).

PPG-275 "Surface Multipole Guide Field for Plasma Injection", R.A. Breun, B.H. Rael, & A.Y. Wong, Review of Scientific Instruments 48 (1977).

PPG-276 "Higher Order Adiabatic Invariants and Non-Adiabatic Diffusion for Geometric Mirrors", Y.C. Lee, T.K. Samec, & B.D. Fried, Phys. Fluids, 20, 815 (1977).

PPG-277 "Electromagnetic Interactions with Inhomogeneous Plasmas", A.Y. Wong. Submitted to Nuclear Fusion and RPI Oct. (1976).

PPG-278 "The Importance of Electrostatic Ion-Cyclotron Instability for Quiet-Time Proton Auroral Precipitation", M. Ashour-Abdalla & R.M. Thorne, Geophys. Res. Lett., 4, 45, (1977).

PPG-279 "Self Channeling of Whistler Waves", E.S. Weibel, Phys. Letts. 61, 37 (1977).

PPG-280 "Formation of Potential Double Layers in Plasmas", B.H. Quon & A.Y. Wong, Phys. Rev. Letts., 37, 1393 (1976).

PPG-281 "Plasma Confinement by Surface Magnetic Fields", T.K. Samec.

PPG-282 "Kinetic Theory of Tearing Instabilities", J.F. Drake & Y.C. Lee, Phys. Fluids 20, 1341 (1977).

PPG-283 "Jupiter's Magnetosphere", C.F. Kennel & F.V. Coroniti, Annual Rev. of Astro. & Astrophys., Submitted Nov., 1976.

PPG-284 "Direct Density Display with a Resonance Cone RF Probe", J. Ickovic, R.L. Stenzel & W. Gekelman, Rev. of Scientific Instr. 48, 485 (1977).

PPG-285 "The Ponderomotive Effect in a Magnetized Plasma", E.S. Weibel.

PPG-286 "The Fluid Theory of the Ponderomotive Effect in a Magnetized Plasma", E.S. Weibel.

PPG-287 "Possible Origins of Time Variability in Jupiter's Outer Magnetosphere", F.V. Coroniti & C.F. Kennel, Geophy. Res. Lett., 4, 287 (1977).

PPG-288 "Coupling of Lower-Hybrid Radiation at the Plasma Edge", G.J. Morales, Phys. Fluids, 20, 1164 (1977).

PPG-289 "Nonlinear Evolution of Collisionless and Semi-Collisional Tearing Modes", J.F. Drake and Y.C. Lee, Phys. Rev. Lett. 39, 453 (1977).

PPG-290 "Model Analysis for Shear Stabilization of Collisionless Drift Waves", Y.C. Lee & T. Tange.

PPG-291 "Particle Orbits and Loss Regions in UCLA Tokamaks", C.P. Lee, January (1977)

PPG-292 "Generation of Density Cavities and Localized Electric Fields in a Nonuniform Plasma", G.J. Morales & Y.C. Lee, Phys. Fluids, 20, 1135 (1977).

PPG-293 "Simulation Study of Bernstein Modes", T. Kamimura, T. Wagner & J.M. Dawson. Submitted to Phys. Fluids (1977).

PPG-294 "Surface Trappings of Oxygen in Tokamaks and its Removal", Lena Oren and R.J. Taylor.

PPG-295 "Low-Z Impurity Control for Reactor Size Tokamaks", R.J. Taylor and L. Oren.

PPG-296 "Computer Simulation of Current Penetration in a Plasma", A.T. Lin and J.M. Dawson, Submitted to Phys. Fluids, March, 1977.

PPG-297 "The Alfven-Ion Cyclotron Instability: Its Physical Mechanism and Observation in Computer Simulation", T. Tajima, K. Mima, and J.M. Dawson, Phys. Rev. Lett. 39, 201 (1977).

PPG-298 "Phase Mixing in the Continuous Spectrum of Alfven Waves", P.L. Pritchett & J.M. Dawson, Phys. Fluids, Submitted May, (1977).

PPG-299 "Nonlinear Evolution of the Collisionless Tearing Mode", F.V. Coroniti, Phys. Rev. Lett. 38, 1355 (1977).

PPG-300 "Active Stimulation of Ionospheric Plasma", A.Y. Wong, April, 1977.

PPG-301 "Confinement of High β Toroidal Plasmas and Currents in Surface Magnetic Fields", D. Mamas, R.W. Schumacher, A.Y. Wong and R.A. Breun, submitted to Phys. Rev. Lett.

PPG-302 "Super Conducting Surmacs", A. Wong and L. Miller, May (1977).

PPG-303 "Plasma Heating by a Relativistic Electron Beam with Secondary Instabilities", T. Tajima. Submitted to J. Plasma Phys.

PPG-304 "Langmuir Waves in a Spatially Periodic Potential", A. Baños, E.S. Weibel, and J.W. VanDam, Phys. Fluids, submitted June, 1977.

PPG-305 "Quasi-Linear Theory for Non-Uniform Turbulence", E.S. Weibel, June, 1977.

PPG-306 "Kinetic Theory of the Internal m = 1 Resistive Mode," J. F. Drake, Y. C. Lee, L. Chen, P. H. Rutherford, P. K. Kaw, J. Y. Hsu, and C. S. Liu. Submitted to Phys. Fluids.

PPG-307 "Some Safety Considerations in Laser Controlled Thermonuclear Reactors," T. E. Botts, D. Breton, C. K. Chan, S. I. Levy, M. Sehnert, and A. Z. Ullman.

PPG-308 "Some Safety Considerations for Conceptual Tokamak Fusion Power Reactors," W. E. Kastenberg, and D. Okrent.

PPG-309 "Coupling of Tearing Modes by Toroidal Effects," J. F. Drake. July, 1977.

PPG-310 "Stabilization of the Alfven-Ion Cyclotron Instability in Inhomogeneous Media," T. Tajima and K. Mima, submitted to Phys. Fluids.

PPG-311 "Particle-Caviton Interactions," A. Y. Wong, P. Leung, and D. Eggleston. Submitted to Phys. Rev. Lett., August, 1977.

PPG-312 "Nonlinear Evolution of Drift Alfven and Double Tearing Instabilities," A. T. Lin. Submitted to Phys. Fluids, August, 1977.

PPG-313 "Atlanta Abstracts - Papers to be Presented at Atlanta Meeting of the American Physical Society Division of Plasma Physics, November 7 - 11, 1977."

PPG-314 "Self-Consistent Potential for a Relativistic Magnetized Electron Beam Through a Metallic Boundary," T. Tajima and F. Mako.

PPG-315 "A Magnetohydrodynamic Particle Code for Fluid Simulation of Plasmas," J. N. Leboeuf, T. Tajima and J. M. Dawson.

PPG-316 "Stability Theory of a Relativistic Electron Beam-Plasma System with Finite Geometries," T. Tajima.

PPG-317 "Anomalous Diffusion and Resistivity of a Turbulent Plasma," R. L. Stenzel and W. Gekelman, submitted to Phys. Rev. Lett., September, 1977.

PPG-318 "Properties of Large Amplitude Langmuir Solitons," M. D'Evelyn and G. J. Morales, submitted to Phys. Fluids, August, 1977.

PPG-319 "End Plugged Long Straight Systems for Thermonuclear Reactors," J. M. Dawson, October, 1977.

PPG-320 "Diffuse Auroral Precipitation," M. Ashour-Abdalla and C. F. Kennel, October, 1977.

PPG-321 "Modulational Instability of Strongly Dispersive Drift Waves and Formation of Convective Waves," K. Mima and Y. C. Lee. Submitted to Phys. Rev. Lett., October, 1977.

PPG-322 "Some Safety Considerations for Conceptual Fusion-Fission Hybrid Reactors," W. Kastenburg and D. Okrent. October, 1977.

PPG-323 "Space-Time Resolved Line Radiation in Microtor-Macrotor Tokamaks," L. Oren and R. J. Taylor.

PPG-324 "Efficiency of Antenna Coupling and Propagation of Fast Alfven Modes in Macrotor," G. J. Morales and R. J. Taylor.

PPG-325 "Topology of Cr Influx in Tokamaks," L. Oren and R. J. Taylor.

PPG-326 "Introduction to Experimental Plasma Physics, Vol. I," A. Wong, November, 1977.

PPG-327 "Inductive Reconnection at an X-type Neutral Line," F. V. Coroniti and M. Ashour-Abdalla, November, 1977.

PPG-328 "Computer Simulation Study of Waves in Bounded Plasma with Application to Lower Hybrid Heating," Viktor Decyk, Dissertation, November, 1977.

PPG-329 "Double-Layer Forward Shocks in an MHD Fluid," T. Tajima, J. N. Leboeuf, and J. M. Dawson. To be submitted to Phys. Rev. Lett., December, 1977.

PPG-330 "Particle Orbits and Loss Regions in the UCLA Tokamaks," A. Baños Jr., and C. P. Lee.

PPG-331 "Computer Model for Bounded Plasma," Viktor K. Decyk and John M. Dawson, submitted to the J. of Computational Physics, December, 1977.

PPG-332 "Interchange Instabilities in a Compressible Plasma," P. Pritchett, C.C. Wu and J. Dawson. Submitted to Phys. Fluids, December, 1977.

PPG-333 "CO_2 Laser Thomson Scattering from a Pulsed Hydrogen Arc." W.A. Peebles and M.J. Herbst. January, 1978.

PPG-334 "Plasma Simulation on the UCLA CHI Computer System," J.M. Dawson, R.H. Huff and C-C Wu. To be published in the Proceedings of the 1978 National Computer Conference. January, 1978.

PPG-335 "Kinetic Theory of m = 1 Internal Instabilities," J.F. Drake, submitted to Phys. Fluids, January, 1978.

PPG-336 "Magnetic Field Generation by the Rayleigh-Taylor Instability," T. Tajima, K. Mima, and J.N. Leboeuf. To be published in the Proceedings of Topical Meeting of Inertial Confinement Fusion (CLEOS). February, 1978.

PPG-337 "Kinetic Theory of Ballooning Instabilities," Y.C. Lee and J.W. VanDam. To be published in the Proceedings of the High-Beta Tokamak Theory Workshop, Varenna, 1977 (by the U.S. DOE). February, 1978.

PPG-338 "Excitation of Lower Hybrid Waves in a Finite Plasma," V.K. Decyk, J.M. Dawson, and G.J. Morales, submitted to Phys. Fluids. February, 1978.

PPG-339 "Explosive Tearing Mode Reconnection in the Magnetospheric Tail," A.A. Galeev, F.V. Coroniti, and M. Ashour-Abdalla, March (1978).

PPG-340 "Small Amplitude Waves in a Hot Relativistic Two Fluid Plasma," S. Hyun and C.F. Kennel, March (1978).

PPG-341 "Nonlinear Evolution of Tearing Instabilities: Violations of Constant ψ," J.F. Drake, P.L. Pritchett, and Y.C. Lee. Submitted to Phys. Rev. Letts., March (1978).

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A computer simulation study of the launching of lower hybrid waves by external sources and their propagation in a finite but homogeneous plasma slab is presented. The study makes use of a 2-½ dimensional, electrostatic particle code developed for simulation of bounded plasma. A number of antenna configurations are considered: a point source, two finite-length capacitor plates, and a phased array of capacitor plates. When the oscillating frequency does not match a bounded plasma resonance, one can observe

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resonance cones, energy absorption at the plasma surface, ion cyclotron modulation of the source, and energetic ions, depending on the parameters chosen. The excitation of a bounded plasma resonance is also considered. The nonlinear evolution of the resonance shows that wave-particle interactions and ponderomotive force effects play an important role. The possibility of controlling the electron temperature profile is discussed.